Considering JPEG2000 for Video Preservation: A Battle for Epistemic Ground

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Abstract
Digitization has become a widely adopted technique for preserving content stored on decaying physical carriers. Understanding the epistemic conditions within which digitization standards develop is an unexplored area of research. This project takes a case-study approach to look at the JPEG2000 standard and the discussion concerning its ability to support a suitable preservation format for analog video content. Following Keller's (2005) sociology of knowledge approach to discourse (SKAD) methodology, this project analyzed 433 messages gathered from the time period 2000 to 2013 on the public discussion board of the Association of Moving Image Archivists (AMIA). This research suggests that for this knowledge community, standards produce contested technological configurations. This research identifies two dominant competing interpretive frames: A frame of *technological innovation*, and a frame of *institutional integration*. The author suggests that considering epistemic registers provides a useful approach for understanding the process of adopting standards for preservation.
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1 Introduction

Standards increasingly impact work done in preservation institutions. Donaldson and Yakel (2013), in their work on the adoption of the metadata standard PREMIS, suggest "standards in archives are ubiquitous. They reflect the most current knowledge about professional practices and increase interoperability, consistency, and the safety and security of collections" (pp. 55-6). Digitization standards are particularly important, as more and more institutions are adopting digitization as a strategy for access and long-term preservation. Paul Conway (2010) suggests that "in the age of Google, nondigital content does not exist, and digital content with no impact is unlikely to survive" (p. 64). Digitization is providing access to the archives of the future, and standards are effectively shaping how collections will appear to future generations. The following research considers one particular standard for preserving collections, JPEG2000, and the debate surrounding its adoption within the moving image preservation community. This research is intended to draw attention to the role standards play in the social distribution of knowledge (Berger and Luckmann, 1966), in particular, how standards shape the storage and presentation practices of preservationists in collecting institutions.

2 Background

2.1 Sociology of Standards

While standards are typically overlooked in our society, they impact us on a daily basis (Busch, pp. 1-2). A variety of scholars have argued for a close sociological reading of standards as key components of institutional infrastructure and important players in the constitution of knowledge production (Bowker and Star, 1999; Brunsson and Jacobsson, 2000; Busch, 2011; Lampland and Star, 2008; Latour, 1987). Timmermans and Epstein (2010) point out that the process of standardization itself can be seen as a form of

knowledge production, suggesting "standardization also raises questions about the role of science and expertise in regulation: What evidence is sufficient or necessary to implement standards?"(p. 70). These approaches demonstrate the close relationship between standards and knowledge, suggesting that the sociology of knowledge may be a fruitful theoretical approach for research into the sociology of standards.

2.2 What is a Standard?

Busch (2011) suggests that "standards are where language and the world meet," implying that the phenomena that we call standards straddle the area between what can be linguistically specified and categorized and the properties of the physical world (p. 3). Standards also invoke categories and make distinctions about things and actions in the world, shaping infrastructure and institutions (Bowker and Star, 1999). In the case of formal technical standards, such as JPEG2000, they are represented in written documents developed through standardizing organizations (e.g. the International Organization for Standardization). These documents may be interpreted by engineers to create specifications for producing objects for commercial distribution. Standards considered at the level of a community define acceptable objects and practices for the carrying out of community practices. Consequently, standards may be considered at the level of documents, technologies, or practices. This research considers the interplay between standards as technology and standards as practices, focusing on the epistemic means by which the JPEG2000 standard is discussed and evaluated by the moving image preservation community.

3 Problem Statement / Research Questions

Antoinette Burton (2005) points out that archival institutions "are not just sources or repositories as such, but constitute full-fledged historical actors as well" (p. 7). Applying this concept to current preservation practices, it becomes clear that the technical process of digitizing documents is not a value-neutral act, but an active shaping of the historical record. This begs the question of how digitization standards become adopted, and in particular, how standards are produced within specific epistemic regimes. To begin an inquiry into these critical issues, this project proposes the following research questions:

- How is JPEG2000 constructed as a preservation format within the discourse of the moving image preservation community?
- What interpretive frames are invoked and how are knowledge claims reinforced or contested? What epistemic registers are invoked in the consideration of this standard?
- Do the concerns over what counts as sufficient knowledge for evaluating preservation formats change over time within this community?

4 Methods and Methodology

4.1 Sociology of Knowledge Approach to Discourse

This research uses the sociology of knowledge approach to discourse analysis (SKAD) developed by Keller (2005), with grounded theory methods (Charmaz, 2006) to look at a corpus of messages posted on the Association of Moving Image Archivists listserv between the years 2000 and 2013, which discuss the potential role of the JPEG2000 format for preservation. The purpose of SKAD is to "analyze ongoing and heterogeneous processes of the social construction - production, circulation, transformation - of knowledge" (Keller, 2005, p. 7). SKAD synthesizes the work of Michel Foucault (1970) on discourse analysis with Berger and Luckmann's (1966) sociology of knowledge. Conceptualizing AMIA-L as a site of knowledge production, this research looks closely at how the epistemic grounds for claims about JPEG2000 are constructed through discourse.

4.2 Selection of Data Source

The Association of Moving Image Archivist's (AMIA) listserv, AMIA-L, was selected as a source of data because of its importance to this community, as it has historically been and continues to be a closely watched listserv by individuals involved in the preservation of moving image media, and it attracts discussants from a wide range of varying backgrounds, including archivists, engineers, corporate vendors, librarians, students, etc. 502 messages between the years 2000 to 2013 were retrieved from the publicly-available archives of AMIA-L using the search terms "JPEG2000 or JPEG 2000. 67 of the messages retrieved were duplicates or were on topics not directly related to JPEG2000. These messages were excluded from the data corpus, leaving 435 (86% of the total messages collected) for analysis. See Figure 1 for the distribution of messages over the period of this study.

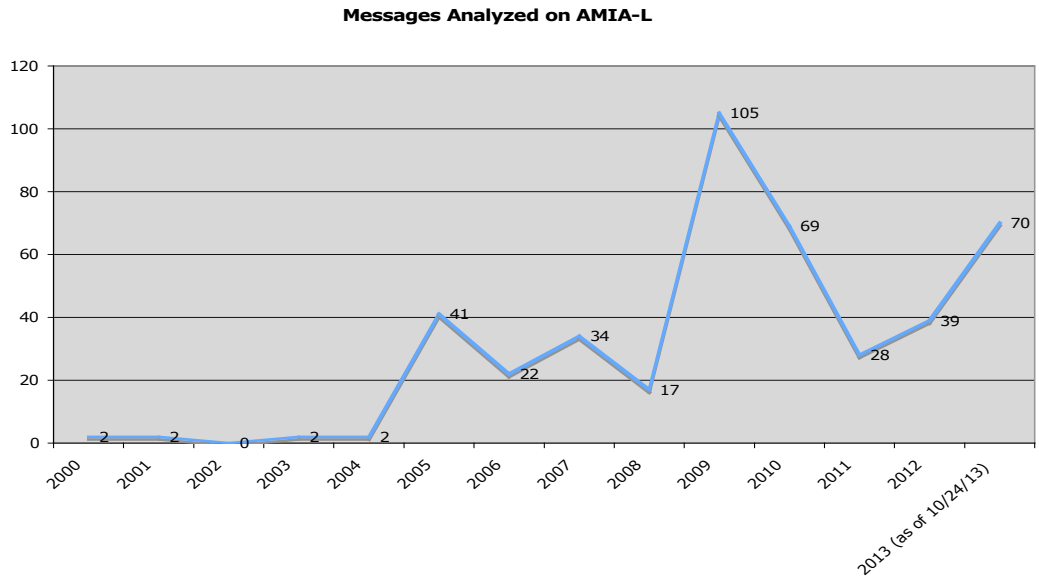

Figure 1: Messages Analyzed on AMIA-L

4.3 Data Analysis

The key elements to analyze in research following SKAD include looking at interpretive frames, classifications, phenomenal structure and narrative structure within the discourse surrounding this standard (Keller, 2005). Grounded theory tools, such as "coding, commentaries and memos" (Keller, 2013, p. 109) are quite helpful in conducting discourse analysis. This project utilizes these tools, coding individual units of enunciation at the word, sentence, and message level, followed by writing memos, recoding documents, and aggregating codes into larger categories for reporting.

After duplicates and off-topic messages were excluded form the analysis, the first pass through the data corpus sought to identify the classification criteria utilized by discussants to make arguments for or against JPEG2000 as a preservation format. In addition, techniques of argument and the presentation of evidence were identified. Subsequent data analysis sessions began to group framing techniques together with epistemic techniques, to form the key interpretive frames identified by this research. In the process of coding, not every message received the same amount or type of analytic focus. Initial analysis focused primarily on clearly positive or clearly negative messages directed at JPEG2000, but it became clear that seemingly neutral messages, which did not take a decisive stand for or against JPEG2000 contributed to understanding the context within which agonistic statements were enunciated. Questions posed to the listserv, required considerable judgment on the part of the researcher to interpret because they could be interpreted as both queries for more information on a certain topic, as well as questions designed to call

into question certain aspects of JPEG2000. Considering the temporal dimension (i.e. coding messages in the context of past and future messages) was essential to making sense of how questions posed to the listserv functioned to promote particular interpretive frames within the context of the ongoing discussion.

5 Findings and Analysis

5.1 Structure of Data Corpus

Figure 1, above, shows the number of messages per year, suggesting a sudden ramp up of discussion from 2004 to 2005, with peak levels of JPEG2000 discussion in 2009 and 2013. Table 1, below, aggregates the institutional affiliation of the discussants for each year. The particular identities of discussants are not directly relevant to the SKAD approach since the concern of this analysis lies in looking at the techniques of knowledge construction and the rules by which knowledge can be formed. However, Table 1 is helpful for providing context and for understanding which segments of the moving image preservation community were actively participating in the discussion. It is significant to the analysis that a small group of discussants appears to be responsible for guiding the discussion. Only 41 discussants engage in the discussion on JPEG2000 over the nearly 14 years of discussion, suggesting that the discourse around JPEG2000 is guided by only a few key figures. The AMIA-L "audience," however, is much larger, constituted by the over 800 individual AMIA members, plus members of the general public who subscribe to the listserv. The presence of a small group of discussants suggests a centralization of power in terms of who can construct the parameters of discourse, which bears further analysis.

	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**Total**
Vendors[1]	0	1 (50%)	0	0	0	21 (49%)	15 (68%)	19 (56%)	11 (65%)	69 (66%)	42 (61%)	16 (57%)	18 (46%)	40 (59%)	**252 (58%)**
National **Archives**[2]	2 (100%)	1 (50%)	0	0	1 (50%)	4 (9%)	3 (14%)	1 (3%)	1 (6%)	7 (7%)	9 (13%)	5 (18%)	6 (15%)	8 (12%)	**48 (11%)**
Medium[3] Archives	0	0	0	0	0	2 (5%)	1 (5%)	1 (3%)	0	0	1 (1%)	1 (4%)	2 (5%)	3 (4%)	**11 (3%)**
Small[4] Archives	0	0	0	0	0	3 (7%)	0	1 (3%)	4 (24%)	20 (19%)	3 (4%)	2 (7%)	1 (3%)	5 (7%)	**39 (9%)**
Academic **Libraries**	0	0	0	1 (50%)	0	3 (7%)	1 (5%)	2 (6%)	1 (6%)	3 (3%)	0	0	0	1 (1%)	**12 (3%)**
Researchers	0	0	0	1 (50%)	0	2 (5%)	0	0	0	3 (3%)	7 (10%)	0	0	2 (3%)	**15 (3%)**
Video Production[5]	0	0	0	0	0	3 (7%)	1 (5%)	1 (3%)	0	1 (1%)	0	1 (4%)	1 (3%)	0	**8 (2%)**
Students	0	0	0	0	0	0	0	1 (3%)	0	0	0	2 (7%)	2 (5%)	0	**5 (1%)**

[1] "Vendors" are commercial entities that provide preservation technologies and services to archives, libraries and museums.

[2] "National Archives" includes U.S. and international archives and libraries with large collections and financial support from national governments.

[3] "Medium archives" cover regional, state and medium-sized specialty collections.

[4] "Small archives" are typically local archives with limited funding.

[5] "Video production" includes video production companies as well as corporate and non-profit broadcasters.

Gov't Agency	0	0	0	0	0	2 (5%)	0	2 (6%)	0	0	0	0	0	0	**4 (1%)**
University **Admin**	0	0	0	0	0	0	0	0	0	0	2 (3%)	0	4 (10%)	3 (4%)	**9 (2%)**
Other/ Unknown	0	0	0	0	1 (50%)	3 (7%)	1 (5%)	6 (18%)	0	2 (2%)	5 (7%)	1 (4%)	5 (13%)	8 (9%)	**30 (7%)**
Total	**2**	**2**	**0**	**2**	**2**	**41**	**22**	**34**	**17**	**105**	**69**	**28**	**39**	**70**	**433**

Table 1: Institutional Affiliation of Discussants on AMIA-L, by Year (% of yearly discussion in brackets)

Looking at Table 1, it is clear that the discussion is dominated by vendors who provide preservation equipment or services (producing 58% of total messages). Their ability to form knowledge claims depends on their presentation of technical knowledge and experience in serving the community's preservation needs on an ongoing basis. These discussants have a financial incentive to shape the discussion to their advantage. However, if they are to be successful in encouraging others to adopt JPEG2000 or one of several competing technologies for digitizing video, they must make their arguments within the discursive constraints of the greater moving image preservation community. After the participation of vendors, individuals associated with national archives (11%) and small archives (9%) contributed the most, on an individual basis, to the discussion. If we aggregate the discussants associated with academic institutions (combining academic libraries, researchers, students and university administrators) we can see that "academia" accounted for 9% of the total messages. Together these three groups, national archives, small archives and academia accounted for only 29% of the discussion. Vendors clearly have considerable influence over how the discourse is constructed in this forum, yet in the following analysis, it will be clear that vendor-domination is only one narrative that can be identified from the discursive construction of JPEG2000.

5.2 Battle of Interpretive Frames

The analysis suggests that *technological innovation* and *institutional integration* are competing interpretive frames vying for dominance during the period analyzed. The *technological innovation* frame is characterized by the idea that its status as an internationally recognized standard and its advanced features make JPEG2000 the most appropriate solution for preserving analog video content. This frame is also supported by concern for the integrity of moving images as evidence. JPEG2000, framed as a standards-based "mathematically lossless" technology for compressing visual information, constructs digitization as a process of exact copying, where fidelity to an original is of paramount concern. Using lossy compression formats, which lose visual information through the encoding process, represents a corruption of the information contained within the analog video signal. JPEG2000 is reported to be a reversible compression process, and the particular implementation under consideration supposedly captures non-visible information such as line 21 information for closed captioning and vertical interval time code information used in video editing.

This frame also positions the innovative technology as both fitting a set of pre-determined, presumably *universal* criteria, as well as acting as the next rational step in a narrative of technological progress.

> "JPEG2000 is a standard that has many advantages over the others you mentioned - one of the very important aspects is the ability to generate low and high resolution proxies from the same file without having to store additional copies. … I strongly recommend a hard look at JPEG2000. JPEG2000 forms the basis of the file format for Digital Cinema and has a strong following in many fields" (AMIA-L, 5/8/05).

In the above example, we can see how JPEG2000 is positioned as an authoritative standard, that it possesses new features and has been adopted by other significant communities concerned with digital imaging.

The competing interpretive frame, *institutional integration*, suggests that solutions should be considered in light of the institution's specific context, including its infrastructure, users, funding sources and size. For instance, a very large institution such as the Library of Congress can afford to buy the complex technology needed to support preservation formats built on the JPEG2000 standard, while smaller institutions may not be able to follow due to social, economic or infrastructural limitations. This frame effectively rejects JPEG2000 as a viable standard for widespread community adoption, instead proposing a variety of alternative approaches based on specific institutional configurations.

> "I don't think the answer is as simple as saying 'choose one codec over another'. There are too many considerations to take into account, and too many unknowns. … it is mentioned that this will be for preservation, but what is the future use of the files? How much storage does the archive have available? How much future storage can they afford? ... You first must start by understanding your users, and having a firm grasp on your goals. You can't just say that one format is the best for all applications" (AMIA-L, 9/13/05).

In response, the supporters of the *institutional integration* frame began marshalling an assault on the various technological claims and the purported innovative qualities espoused by the JPEG2000 creators.

> "THERE IS NO INDUSTRY CONSENSUS on the best way to archive video. The path an organization takes is determined by a large number of factors. Among the most important are resources, personnel and the goals/mandates of the archive. It is great that the cost per gig of storing video on drives and data tape are coming down. For preservation purposes, that cost may not be the most important to the archive" (AMIA-L, 2/10/09, emphasis in original).

The use of capital letters in the beginning of this quote works to emphatically question the status of JPEG2000 as a standard, based on the presentation of evidence indicating that it has not been widely adopted. The above example illustrates how JPEG2000 is positioned by detractors as an inflexible technology that does not easily integrate with the institutional context or fulfill the needs of expected users of digitized content. Supporters of JPEG2000 respond to these types of attacks on JPEG2000 by minimizing the ongoing problems identified by opponents as evidence against JPEG2000, such as issues with interoperability (i.e. being able to properly playback digitally encoded content on different systems):

> "I do not know of what 'inop problems' you are talking about with JPEG2000 at this point in time. 4 or 5 years ago there were just a few... ummm... uhhh... proponents […] but at this point in time there are multiple levels of support from multiple vendors, and many projects are now specifying j2k as the preservation format of choice for SD video" (AMIA-L, 4/5/11).

In addition, JPEG2000 supporters draw on the assumptions of *preservation ethics* to enhance their claims that JPEG2000 is a technology that supports the existing standards of the archival community. Examining other technologies by looking at the quality of images they produce is seen as an unacceptable manner of assessing quality in digitization: "I have a very hard time supporting the 'I can't see a difference so it's fine' philosophy of AV Archiving" (AMIA-L, 2/27/10). Such messages imply that employing formats other than lossless JPEG2000 compression is an indication of a flawed approach to archival preservation. By repositioning the innovation as a marker of adherence to preservation ethics, the *technological innovation* frame constructs the use of JPEG2000-based formats as a way of differentiating the true preservationists from those doing what is merely expedient.

In the last two years of the period of study (2012-2013), detractors posited questions concerning key technological claims of JPEG2000 supporters, which worked to degrade the epistemic support of the *innovation* frame itself.

> "Is someone able to point me towards any reports or documentation that detail the evidence for Jpeg2000 offering true lossless compression? I have realized that while I have many references around this, none of them detail actual testing that has proven this" (AMIA-L, 4/10/13).

By calling into question the basic technical attributes of JPEG2000, detractors seek to destabilize the existing knowledge on JPEG2000, specifically its technical abilities to produce losslessly compressed files. By casting doubt on this essential attribute, this seemingly innocuous question problematized the purported innovation's technological attributes.

5.3 Epistemic Techniques

Analysis of the data suggests the following forms of knowledge techniques are mobilized to support or refute JPEG2000 as a standard:

- Statement of fact: Statement to be taken as true evidence, often supported by *expert positioning* (see below).
- Anecdotal evidence: Personal experience offered as evidence, typically bolstered by positioning as expert or long-time member of the community.
- Rhetorical flourishes: Humor, irony, tropes, emoticons, etc. used as convincing gesture, encouraging trust, or lightening tension in heated debate.
- Instrument-based knowing: Use of machines, scopes, algorithms, etc. to verify truth claims. The dominant *innovation* frame elevates machine vision and calculations, while denigrating educated human perception as reliable verifier of truth claims and quality.
- Documentary evidence: Discussants typically provide links to external documents or webpages; supply copies of code or computer output as evidence; reference documents; or provide footnotes to support arguments.
- Calculations: Discussants will often write out the steps of a basic arithmetic calculation as a performative display of evidence to support a particular argument.

In addition, two additional techniques, *expert positioning* and *querying* were identified that deserve special explanation. *Expert positioning* is an emergent theme that involves a particular discussant positioning him or herself as an expert by using anecdotal evidence such as statements about length of involvement in the field, association with notable organizations, presentations made at conference, etc. to give credibility to statements and make the particular individual appear as an authority on the topic under consideration. The common use of email signatures at the end of posted messages, often providing information about institutional affiliation, job titles or other credentials, plays a significant, although often unnoticed role in defining the authority of a discussant's statements. Of the messages analyzed, 85% (365) had signatures displaying institutional affiliation. *Queries* on the other hand are questions posed to the list that decrease the credibility of other discussants and their claims about JPEG2000: "Can you point to reports showing results of interoperability tests of MXF-wrapped JPEG2000 files created on one application and played back/rendered on another vendor's product?" (AMIA-L, 4/10/13). This query on the AMIA listserv, seemingly neutral, effectively calls into question the claims by JPEG supporters that the ongoing interoperability issues associated with JPEG2000 had been solved. Shifting the focus of the debate to the unresolved interoperability problems associated with JPEG2000 destabilizes the claims of the JPEG supporters that JPEG conforms to preservation ethics. Interoperability is seen as a critical attribute of a preservation format since it ensures that files can be exchanged with other institutions and that files can be accessed on other software and hardware configurations into the future.

5.4 Shifts in Epistemic Grounds

The preceding list suggests the range of epistemic techniques employed in the debate over this standard during this time period. The most common form of argumentation relies on documentary evidence to support its claims. Statements of fact and anecdotal evidence are common as well, relying on the positioning of the speaker as an expert and/or long-time member of the community.

A key finding of this research is that, over time, the detractors of JPEG2000 began to move the focus of their debate against JPEG2000 from the particular claims made by supporters to the grounds on which these claims were being made. The detractors of JPEG2000 appear to continually shift the burden of proof back from rhetoric to direct experience with the technology, constituting an emergent theme termed *individual technological engagement*, which privileges individual experience with technology over the knowledge of experts. While an economic approach might suggest that the lack of widespread adoption of JPEG2000-based technology is due to economies of scale and the limited revenue streams of small organizations, using the SKAD approach, we can see that another important factor may be conflicting expectations within the community about the epistemic grounds upon which a technology may be understood. These shifting epistemic grounds may be linked back to historical changes within the preservation field through additional analysis, as discussed below in 6.1 Future Directions. Table 2, below, identifies key moments in the development of JPEG2000 that could be further explored through interviews with the key individuals involved.

2000	JPEG 2000, Part 1 becomes an International Standard (ISO/IEC 15444-1) http://www.iso.org/iso/catalogue_detail?csnumber=27687
2001	JPEG 2000, Part 3 (for moving images) becomes an International Standard (ISO/IEC 15444-3) http://www.jpeg.org/jpeg2000/j2kpart3.html
2002	
2003	
2004	*Digital Video Preservation Reformatting Project (*a report by Media Matters for the Dance Heritage Coalition analyzing options for preserving analog video content; used in AMIA-L discussions as a key document to support the argument for using JPEG2000). http://www.danceheritage.org/digitalvideopreservation.pdf
2005	The Library of Congress adopts the use of JPEG2000 file format for preserving images. http://memory.loc.gov/ammem/help/mrsid.html
2006	
2007	Federal Agencies Digitization Guidelines Initiative (FADGI) is launched under the auspices of the National Digital Information Infrastructure and Preservation Program (NDIIPP) at the Library of Congress. http://www.digitizationguidelines.gov/
2008	
2009	Library of Congress adopts JPEG2000 for digitizing video collections. Library of Congress – NAVCC Begins transferring analog video tapes to MXF wrapped JPEG2000 files. http://www.loc.gov/avconservation/preservation/projects.html JPEG2000 Alliance Formed, http://www.jpeg2000alliance.com/?page_id=2
2010	
2011	*JPEG2000 Summit* (Library of Congress, May 12-13), http://www.digitizationguidelines.gov/resources/jpeg2000.html
2012	
2013	

Table 2: Events in JPEG2000 History

6 Limitations

As a case study, the findings of this research are limited to the specific standard and community analyzed. In addition, analysis was limited to one forum of knowledge exchange, the popular AMIA-L listserv. Clearly, the public debate surrounding JPEG2000 took place in other forums, such as the ongoing work of Federal Agencies Digitization Guidelines Initiative, academic and practitioner-authored journal publications, and a variety of conferences, including the annual AMIA conference. Additional research to triangulate data across these forums is necessary. Some of the key events in the history of JPEG2000, in need of further study, appear in Table 2, above.

6.1 Future Directions

The SKAD approach may be useful for other examinations of technology diffusion. *Diffusion of innovations* (Rogers, 2003) approaches could be enhanced by affording weight to the role that knowledge techniques play in determining how technologies are adopted across a community. In addition, Backhouse, et al. (2006) suggest a fruitful direction for considering standards within a *circuits of power* framework, which might be enhanced by using SKAD to examine how the social distribution of knowledge contributes to the configuration of circuits of power. Finally, further analysis of documents and events surrounding the adoption of preservation standards in the moving image preservation community can help explore the genealogical dimension of Foucault's approach to discourse analysis. For instance, we might consider the role played by the consolidation of institutional power when the Library of Congress became an early adopter of new preservation technologies (such as JPEG2000), encouraging small organizations to follow suit, or in terms of the changing professionalization of the field as graduate-level programs at universities begin to replace long-term apprenticeships as the dominant forms of training.[6] These are just a few of the possible historical events that may be linked back to the discourses associated with the adoption of preservation standards.

7 Conclusion

The case of JPEG2000 as a standard considered for preserving analog video content provides an illuminating case study for the playing out of discourses in the construction of a preservation standard. JPEG2000 was adopted by the Library of Congress as a standard for both preserving still images (in 2005) and video (in 2007). The issue of whether JPEG2000 should be adopted by the greater preservation community is still hotly debated.

This research suggests the usefulness of taking a SKAD approach for extending our conceptualization of how the members of a heterogeneous knowledge community debate the adoption of a standard, including better understanding the possible range of epistemic techniques they employ, and the potential shifts in interpretive frames and epistemological grounds that may be observed over time. This work seeks to contribute to a growing body of literature on the sociology of standards, drawing attention to the complex role standards play within communities tasked with preserving cultural heritage collections, and the role that standards play in the social distribution of knowledge (Berger and Luckmann, 1966). In addition, it offers new insight into a community of preservationists engaged in generating knowledge about a new, and potentially disruptive, preservation technology through ongoing debate, offering insight into how archivists work to shape the traces of the historical record in the age of *digitization for preservation* (Conway, 2010).

[6] University of California - Los Angeles and New York University both started their own graduate-level moving image preservation programs in the early part of the time period under analysis, in 2002 and 2003, respectively.

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